Jemena Northern Gas Pipeline Pty Ltd

Northern Gas Pipeline

Draft Environmental Impact Statement

APPENDIX M – DESKTOP GEOTECHNICAL STUDY (JULY 2015)

Public

Jemena

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Integrated Practical Solutions

Report on
Desktop Geotechnical Study

Proposed North East Gas Interconnector Pipeline
Tennant Creek to Mt Isa District

Prepared for
Jemena Pty Ltd

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Report on Desktop Geotechnical Study
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1. Introduction

This report presents the results of a desktop geotechnical study for the proposed North East Gas Interconnector Pipeline project which will extend from Tennant Creek (Northern Territory) to Mt Isa (Northwestern Queensland). The study was commissioned by Mr Richard Henderson of Jemena Pty Ltd (Jemena) via Purchase Order 4100115336 dated 23 June 2015 and was carried out in accordance with Douglas Partners (DP) proposal dated 17 June 2015.

It is understood that the construction of a 625 km pipeline is proposed between Warrego, Tennant Creek and Mt Isa, linking the Amadeus Pipeline and Carpentaria Pipeline, respectively. The gas pipeline will be of steel construction and placed in a trench at about 1.25 m depth.

Additional structures within envelopes of up to approximately 300 m square are also proposed and include:

- Compressor Stations (CP1 to CP4);
- Main Line Valves (MLVs 1 to 4); and
- End of Line (EOL) Delivery Stations.

The initial study corridor is 10 km wide in total, whilst the final easement is anticipated to be less than 100 m wide.

It is further understood that the desktop geotechnical study will be largely used as part of Jemena's construction planning, preliminary design and financial analysis for the project, and to a lesser degree, to assist with planning of an intrusive geotechnical investigation for the pipeline. The purpose of the study was to:

- assess major geological and geomorphological features in the project area;
- assess the geology and soils of the sites affected by the project, with particular reference to the likely physical and chemical properties of the surface and subsurface materials and geological structures likely to be intercepted during construction;
- provide comment on the project in the context of major geological and geomorphological features and any measures taken to avoid or minimise the impact of same; and
- develop basic interpreted geotechnical/geological models along the alignment on the basis of geological/terrain units.

The desktop study included a review of locally available topographical and geological maps in conjunction with past investigation carried out by DP in the vicinity of the proposed route.

2. Key Geotechnical Project Issues

The following issues are considered critical to the project from a geological and geomorphological perspective:

- drainage lines, which may preclude access during wetter months;
- alluvial channels, which may contain relatively deep unconsolidated soils and potentially shallow groundwater, including guidance on methods for predicting scour depth and possible protection measures if scour is of concern;
- sodic or dispersive soils, which may give rise to erosion and high turbidity runoff problems;
- highly expansive soils (possibly associated with weathering of some fine grained Mesozoic aged rocks on the Barkly Tableland), which may require special attention for foundation design;
- karstic terrain (especially in the Georgina Basin), which could be susceptible to sink-holes;
- naturally occurring upland acid sulfate soils, which may generate acidic leachate if disturbed;
- aggressive soils (to buried steel and concrete structural elements), which may require specific design and construction precautions;
- natural mineralisation (especially in the Mt Isa Block), which may present occupational health and safety hazards;
- excavation of the shallower granites, volcanics and metamorporphics closer to Tennant Creek and Mt Isa; and
- unstable geological formations and landslide or debris flow hazards and areas of potential liquefaction, which may impact on the route safety and long term maintenance.

3. Route Alignment – Topography and Geology

Based on the information presented on published maps and accompanying notes by the Department of Mines, the proposed pipeline alignment will generally cross the following geological units and topography between Warego and Mount Isa:

- Warego to Point 1 (53K E:455744 N:7844459) – sand plain deposits flanking a north-west to south-east trending ridge of folded and faulted sedimentary greywacke, sandstone, siltstone and shale intruded and interbedded with acid igneous strata.
- Point 1 (53K E:455744 N:7844459) to Point 2 (53K E:597856 N:7798719) – sand plain deposits with some outcrops of limestone, chert and breccia (Barkly Tablelands).
- Point 2 (53K E:606643 N:7795808) to Point 3 (53K E:715780 N:7756895) – hill of relatively low relief characterised by sand plain deposits with some sand dunes, calcrete and outcrops of chertified limestone and mudstone, dolostone around its lower reaches. The later 'solid' geology is also predominant across the top of the hill.
- Point 3 (53K E:715780 N:7756895) to Point 4 (53K E:249505 N:7705012) – large floodplain of low relief characterised by numerous river channels flanked by alluvium with the intervening areas underlain by 'black soil'. Chertified limestone and mudstone, dolostone in the west, and limestone

in the centre and east underlie the superficial soils and are depicted locally outcropping along river channel.

- Point 4 (54K E:249505 N:7705012) to Point 5 (54K E:292978 N:7704201) – gently falling foothills of the Selwyn Range, characterised by alluvium and sheet wash deposits.
- Point 5 (54K E:292978 N:7704201) to Mt Isa – gently sloping terrain, dissected by several north-south to northeast-southwest trending ridgelines. Geology is variable with folded and faulted sedimentary rocks intruded and interbedded with igneous strata with little superficial cover.

Digital versions of the maps i.e. route alignment and geological conditions, used in the desktop study are presented in Drawings 1 to 5 in Appendix B. All elevations are relative to Australian Height Datum and co-ordinates are given in UTM system WGS84.

3.1 Warego to Point 1 – Drawing 2

The Warego to Point 1 (53K E:455744 N:7844459), 70 km section of the alignment comprises relatively rugged terrain and traverses a near north-west to south-east trending ridge line, which itself is characterised by irregular, locally curved ridges with intervening watercourses. Local surface relief is typically about 20 m, rising from approximately RL 315 m at Warego to RL 380 m near the centre of the ridgeline, before descending to RL 350 m at the intersection of the alignment and the Stuart Highway. East of the highway the alignment falls gently towards Point 1 which is at an elevation of RL 300 m

Based on geological map SE 53-14, 'Tennant Creek' sheet at 1:250,000 series published in 1998 by the Department of Mines and Energy, the geology along this section of the alignment is slightly variable and typical of a sedimentary sequence which has been folded, faulted and intruded by igneous rocks. The pipeline corridor is also dissected by numerous mostly north-west to south-east orientated faults. A summary of the geology in the area, based on distances from Warego, is given in Table 1.

Table 1: Summary of Geology (Warego to Point 1)

Approximate Distance (km)	Map Unit	Description
0 – 4	Qr	Red earth soils; may have ferruginous pisoliths.
4 - 8	Qc	Colluvium, scree.
8 - 9.5	Qs, Czs - Pw_m	Sheet and dune sand, sandy soil with a central outcrop of Warramunga Formation comprising fine to medium grained lithic arenite including volcanic arenite (metagreywacke?) siltstone, shale and terrigenous mudstone; minor phyllite; red, green and purple weathering shale; pencil shale, thin to medium bedded, parallel- or cross-laminated. Lithic arenite subordinate or subequal to siltstone and shale. 'Haematite shale'. Partial Bouma sequences. The Warramunga Formation is shown to be locally folded with some minor faulting.
9.5 – 12.5	Qc, Pw_m, Qr, Czc	Ridge of Warramunga Formation (described above) flanked by deposits of colluvium, scree, red earth soils and sheet sand.

Table 1 (cont): Summary of Geology (Warego to Point 1)

Approximate Distance (km)	Map Unit	Description
12.5 – 16.5	Qr	Red earth soils; may have ferruginous pisoliths. Towards its eastern end, the section parallels an outcrop of Warramunga Formation located to the north and a moderate size fault is mapped trending north-west to south-east to the west of the outcrop.
16.5 - 24	Qr, Qs	Red earth soils; may have ferruginous pisoliths, and sheet and dune sand, sandy soil.
24 - 33	Qc, Czc, Qs localised Pgt	Deposits of colluvium, scree, sheet sand and dune sand, sandy soils with outcrops of Tennant Creek Granite. Large outcrop of granite mapped to the south with north-west to south-east trending faults flanking it which extend northwards and dissect the alignment. Subsidiary north-east to south-west trending faults are also depicted.
33 - 41	Qc localised Czs and Pgt	Deposits of colluvium, scree and thin sheet sand and dune sand, sandy soils with outcrops of Tennant Creek Granite.
41 - 51	Pgt	Ridge of Tennant Creek Granite with some near north – south trending minor faulting.
51 - 52	Qc	Colluvium, scree.
52 - 54	Pgt, P_m, Emg - Qs	Outcrop of Tennant Creek Granite flanked by Warramunga Formation (previously described) and Gum Ridge Formation comprising certified bioclast onkoid and cryptomicrobial limestone, marly calcimusdtone, minor siliclastic mudstone: carbonate and evaporate nodules; basal maroon-purple sandstone and maroon-brown siliclastic mudstone; fossiliferous. Sheet and dune sand, sandy soil are mapped to the north and south.
54 – 56.5	Qs, Qa	Alluvial deposits in active channels and on floodplains and Sheet and dune sand, sandy soil. Alluvial soils are associated with southward draining tributary of the larger Tennant Creek.
56.5 – 60	Emg, Qc, Qa, Qs	Ridge of Gum Ridge Formation (previously described) flanked by colluvium and scree with deposits of alluvium and sheet sand/dune sand to the north and south.
60 – 63.5	Qa	Alluvial deposits in active channels and on floodplains.
63.5 – 66.5	Emg, Pgt, Qc, Czs	Ridge of Gum Ridge Formation (previously described) with localised Tennant Creek Granite flanked by colluvium and scree, and sheet sand or sandy soil.
66.5 - 75	Qs	Sheet and dune sand, sandy soil.
75 - 80	Pw,Emg, Qc	Ridge of Warramunga Formation (previously described) with Gum Ridge Formation (previously described) in the north flanked by colluvium and scree.

3.2 Point 1 to Point 2 – Drawing 3

This approximately 160 km long section traverses the western half of the Barkly Tablelands in a generally south-easterly direction from the western side of the downstream end of the Goose River to Point 2 (53K E:606643 N:7795808). Working from west to east surface levels fall gently east of Goose River from approximately RL 300 m to RL 250 m over about 50 km and relief comprises flat to rolling plains. Gently undulating conditions then continue to Point 2, with surface levels remaining between about RL 235 m and RL 240 m.

Reference to geological map SE 53-14, 'Tennant Creek' sheet at 1:250,000 series published in 1998 by the Department of Mines and Energy, and map SE 53-15 'Alroy' sheet at 1:250,000 series published in 2010 by Northern Territory Geological Survey, Department of Resources indicates that with the exception of the Goose River, where alluvial deposits (map unit Qa and Qp) associated with it could cover up to approximately 2 km at its narrowest point (i.e. location of proposed alignment crossing) the geology of the alignment is essentially characterised by sheet and sand dune, sandy soils (Tennant Creek map unit Qs) and/or unconsolidated colluvium and aeolian sand, minor silt, red earth (Alroy Map unit Czs).

Towards the eastern end of the section (approximately 15 km north-west of CP2) sand dunes/ridges and mark a change in relief near centrally across the Barkly Tablelands. Continuing eastwards (i.e. between the dunes and Point 2) deposits of calcrete (map unit Czk) with localised claypans (map unit Op) are mapped interspersed with sand plain deposits.

The wider alignment corridor is similarly characterised by sandy deposits with localised outcrops of calcrete, claypans and the Gum Ridge Formation (map unit Emy) comprising dolomudstone/dolosparstone, dolomitic-siliclastic siltstone and mudstone, dolomitic sandstone-siltstone interbeds; nodular and bedded evaporate, chert concretions; minor intraclasts and oncoid dolostone, microbial dololaminite, dolomitic quartz sandstone. Outcrops of these strata are generally mapped as occurring in the north of the corridor at the western end of the section and south of the corridor in the centre of the section.

3.3 Point 2 to Point 3 – Drawing 4

This approximately 120 km section of the alignment essentially traverses a hill of low and undulating relief. Surface levels rise gently south-eastwards from approximately 240 m at Point 2 (53K E:606643 N:7795808), to 280 m where the alignment crosses the aforementioned hill adjacent to MLV2. Surface levels then fall eastwards to approximately 220 m at Point 3 (53K E:715780 N:7756895), just west of CP3.

Based on geological maps SE 53-15 'Alroy' sheet at 1:250,000 series published in 2010 by Northern Territory Geological Survey, Department of Resources and SF 53-04, 'Avon Downs' sheet at 1:250,000 series published in 2005 by Northern Territory Geological Survey, Department of Primary Industry, Fisheries and Mines the lower reaches of the hill predominately comprise unconsolidated colluvium and Aeolian sand, minor silt, red earth (map unit Czs) with lesser sand dune and calcrete with detrital quartz (map unit Czk) deposits. Outcrops of Camooweal Dolostone comprising sandstone, microbial dolostone with siliceous concretions and minor marl (map unit Emd) are also map around the lower reaches of the hill.

Wonarah Formation rocks comprising chertified limestone and mudstone, dolostone (silty dolostone, dolosparstone, calci/dolomudstone-siliciclastic mudstone interbeds); siliceous concretions; minor intraclast and bioclast wacke- to grainstone, oncoid pack- to grainstone, siltstone and sands (map unit Cmw) are shown to be predominant in the west of the section and across the top of the hill with unconsolidated colluvium sand, minor silt covering the 'troughs' between the areas of higher ground.

The Camooweal Dolostone and Wonarah Formation of the Barkly Group are depicted as being moderately to heavily folded and faulted with syncline and anticlines mapped trending in a north-west to south-east orientation and two faults perpendicular to each other with the dominant fault set appearing to trend north-east to south-west.

3.4 Point 3 to Point 4 – Drawing 5

Towards the eastern end of the Barkly Tablelands i.e. between Points 3 (53K E:715780 N:7756895) and 4 (54K E:249505 N:7705012) the 170 km section of the alignment crosses a large floodplain situated between the aforementioned hill in the west and the foothills of the Selwyn Range in the east. The floodplain is relatively 'low-lying' and of flat relief with surface levels falling gently eastwards from Point 3 to between RL 200 m and RL 210 m across the floodplain before gently rising, some 25 km west of Point 4, to RL 245 m. The floodplain is characterised by numerous southward draining tributaries (namely Ranken River, James River Blue Bush Creek, Gidyea Creek and Mingera Creek) of the larger Georgina River.

Reference to geological map SF 53-04, 'Avon Downs' sheet at 1:250,000 series published in 2005 by Northern Territory Geological Survey, Department of Primary Industry, Fisheries and Mines, indicates that the initial 115 km of the floodplain generally comprise grey-black clay rich soil *"black- soil"* (map unit Czb) with alluvium: sand, minor gravel, silty and clay (map unit Qa) flanking the various river channels and creeks. Localised deposits of unconsolidated colluvial sand, minor silt (map unit Czs), regolith, skeletal shallow soil and bedrock (map unit Cz), and calcrete with detrital quartz (map unit Czf) are also mapped.

Similarly, albeit to a lesser extent than above, the Camooweal Dolostone which comprises sandstone, microbial dolostone with siliceous concretions and minor marl (map unit Emd) and underlies the floodplain, is shown locally outcropping adjacent to the larger rivers and creeks which cross cut the section.

Between 115 km and 125 km and essential Gidyea Creek and Mingera Creek, Austral Downs Limestone comprising lacustrine limestone with minor clay, sand and gravel is mapped as being at the surface.

Continuing east the alignment crosses the eastern half of the floodplain, which with reference to geological map SF 54-1, 'Mount Isa' sheet at 1:250,000 series published in 1987 by Department of Mines, Queensland, is underlain by similar conditions to those in the west. Residual soils, colluvium and sheet wash: poorly sorted sand, mud and gravel (map unit TQr) cover most of the area with alluvium, sand, silt clay (map units Qa and Qha) flanking the creeks and river channels. The superficial soils are underlain by Camooweal Dolomite (map unit Ed), which locally outcrops some 145 km east of Point 3.

Further eastwards the transition from the floodplain to the foothills of the Selwyn Range initially comprises similar conditions to the above followed by duricrust, silicrete, ferricrete followed by alluvium of minor sheet wash, sand silt, clay and minor gravel locally feruginised.

3.5 Point 4 to Point 5 – Drawing 6

The Point 4 (54K E:249505 N:7705012) to Point 5 (54K E:292978 N:7704201), approximately 45 km section of the alignment rises approximately 90 m from RL 245 m to RL 335 m as it climbs the foothills of the Selwyn Range. The terrain is characterised by gently south-westward sloping ground and is dissected by the south-westward draining Templeton River at about 10 km east of Point 4.

Reference to geological map SF 54-1, 'Mount Isa' sheet at 1:250,000 series published in 1987 by Department of Mines, Queensland indicates the section to essentially be underlain by alluvium comprising sand, silt, clay and minor gravel (map unit Qa), with minor sheet wash in the east (map unit Qpa).

3.6 Point 5 to Mt Isa – Drawing 6

The Point 5 (54K E:292978 N:7704201) to Mt Isa approximately 60 km long section of the alignment comprises mostly gently sloping terrain, dissected by several north-south to northeast-southwest trending ridgelines. A ridge line with a crest level of about RL 450 m located approximately 10 km west-southwest of the pipeline terminus forms a major break in the terrain, with areas to the west drained by Yaringa Creek, which flows to the southwest and local surface relief of typically up to about 20 m. The areas to the east of this ridge, are drained by Mica Creek and the Leichhardt River, which flow to the north and north east. Most of this section of the alignment falls gently to the east from about RL 400 m to RL 370 m adjacent to the southern side of Mica Creek.

Reference to geological map SF 54-1, 'Mount Isa' sheet at 1:250,000 series published in 1987 by Department of Mines, Queensland indicates the geology in the eastern portion of this area to be variable (from approximately 25 km west of the Diamantina Developmental Road), which is typical of most of the Mt Isa Inlier, which extends in an easterly direction from about 28 km west of the terminus. This area is also dissected by eight mapped fault lines. To the west of the Mt Isa Inlier is the Georgina Basin, which as described above, tends to be less variable geologically. A summary of geology in the area, based on distances from Point 5, are summarised in Table 2 below.

Table 2: Summary of Geology (Point 5 to Mt Isa)

Approximate Distance (km)	Map Unit	Description
0 – 15	TQr/Qpa/Qf/ Pmw/Pr	Gently southwesterly sloping area draining to Yaringa Creek, underlain by Tertiary aged residual soils (colluvium and sheet wash, locally ferruginised), Pleistocene aged alluvium and alluvial fans (sand, gravel, mud), dissected by low southwest-northeast striking ridges underlain by Gunpowder Creek Formation (micaceous and dolomitic siltstone, sandstone) and Surprise Creek Formation (feldspathic sandstone, siltstone).

Table 2 (cont): Summary of Geology (Point 5 to Mt Isa)

Approximate Distance (km)	Map Unit	Description
15 - 19	Qa	Gently southwesterly sloping terrain draining to Yaringa Creek, underlain by alluvial soils.
19 – 24	Py	Residual soils at the footslopes of low southwesterly trending ridges underlain by Yaringa Metamorphics (schist and phyllite, biotite gneiss, migmatite.
24 – 31	Qa	Alluvial soils along Yaringa Creek (sand, silt, clay, minor gravel). Two faults are mapped in this area, although they are concealed by the alluvium.
31 - 35	TQr/Phe/ Phm	Westerly sloping terrain underlain by residual soils, comprising colluvium and sheet wash, locally ferruginised, generally overlying Eastern Creek Volcanics (metabasalt, tuff, sandstone) and Myally Subgroup rocks (sandstone, siltstone), with some outcropping ridges of rock up to 500 m wide.
35 – 45	Pgs/Phe	Westerly sloping terrain underlain by Sybella Granite (foliated porphrytic biotite granite) dissected by north south trending Eastern Creek Volcanics (metabasalt, tuff, sandstone).
45 – 46.5	Phq/Phs	Ridge up to RL 450, comprising mostly Leander Quartzite (orthoquartzite, feldspathic sandstone, phyllite, tuff) with some May Downs Gneiss.
46.5 – 52	Pgs/Phe	Easterly sloping terrain underlain by Sybella Granite (foliated porphrytic biotite granite) flanked to the east by north south trending Eastern Creek Volcanics (metabasalt, tuff, sandstone). Area to the south of the alignment forms the headwaters of Mica Creek.
52 - 53	Phn/Phw	Relatively level terrain on the southern side of Mica Creek, underlain by Lochness Formation (dolomitic feldspathic siltstone and sandstone) and Whitworth Quartzite (feldspathic sandstone and orthoquartzite). Mapped fault on eastern side of the alignment.
53 – 54.5	Pr/ Pin	Mount Isa Group rocks extending from about 500 m west to 1 km east of Diamantina Developmental Road, including Surprise Creek Formation and Native Bee Siltstone (feldspathic sandstone, dolomitic siltstone, some chert and tuff). Mapped faults at about 500 m intervals.
54.5 - 56.5	Phl/Phc	Gently sloping terrain on the southern side of Mica Creek, underlain by Lena Quartzite (orthoquartzite, feldspathic sandstone, siltstone) and Cromwell Metabasalt Member. Leichhardt fault mapped along eastern side.
56.5 - 60	Pib/Plm	Relatively level terrain between Mica Creek and Leichhardt River underlain by Mount Isa Group rocks including Breakaway Shale (grey shale, minor siltstone) and Mondarra Siltstone (dolomitic siltstone, dolomite, shale). One mapped fault at approximately 1.1 km south of terminus.

4. Likely Subsurface Conditions and Previous Investigation

4.1 Warrego to Point 1

Previous investigation in this geological setting is confined largely to Tennant Creek, where four previous investigations, comprising test pits, indicate the subsurface conditions to generally comprise stiff to very stiff and medium dense (or denser) locally loose, mixtures of low plasticity clay, silt, sand and gravel, with silt appearing to be the predominant soil type. Below about 1.5 m to 2 m depth, hard to extremely low strength and very low to low strength siltstone was encountered. Groundwater was not encountered within the investigations.

A shallower soil profile, scree slopes, sheet wash and more rocky conditions are expected as the alignment crosses the ridge with the Tennant Creek Granite, where, encountered, being particularly hard as would the contact rocks around it. Alluvial clayey and sandy soils are also likely to be encountered adjacent to creeks and rivers, but are not anticipated to be of significant thickness.

The results of the investigations and engineering assessments also indicate a low potential for the presence of acid sulfate soils, highly dispersive soils with mild to severe aggressivity conditions.

4.2 Point 1 to Point 2

DP has no records of investigation along this section of the alignment, however, It is generally anticipated that subsurface conditions will be similar to the soil conditions encountered at Tennant Creek albeit with a much high sand content and a deeper rock profile.

4.3 Point 2 to Point 3

Similar to the above DP has no records of investigation along this section of the alignment. It is anticipated based on the Tennant Creek investigations and the geological maps that conditions could comprise mixtures of cemented clay, silt, sand and gravel with a predominance of silt and sand. Strength conditions are generally expected to be relatively strong although variations will occur.

The superficial soils are underlain by chertified limestone and mudstone, dolostone and clastic sediments which are folded and faulted. The depth to rock across most of the section could be a few metres and the rock is anticipated to be relatively weathered, grading from mostly extremely low and very low strength at its upper surface, to low and medium strength increasing with depth. However, where dolomitised and certified strata are encountered stronger and less weathered conditions should be expected. In the east of the section, where the alignment crosses the hill the rock, is anticipated to be encountered at or near surface probably with a shallow weathering profile and competent rock possibly at relatively shallow depth.

4.4 Point 3 to Point 4

DP has undertaken a previous investigation at Alpurrurulam which encountered stiff and hard, medium plasticity, dark red silty clay soils overlying very dense, clayey gravel at less than 1 m depth. No groundwater was observed.

It is anticipated based on the above and the geological maps that the subsurface conditions across the floodplain between Points 3 and 4 could comprise high plasticity and highly reactive clays in the west and alluvial clay, silt and sand with some minor gravels in the east. The soils are expected to be greater than about 3 m thick, with the thickness increasing adjacent to river channels and creeks. The predominantly clay soils are also expected to be ineterbedded with silt and sand layers adjacent to river channel and creeks.

The floodplain soils are also locally characterised by areas of colluvial sand, calcrete and regolith (i.e. localised areas of softer and harder ground). Similarly, localised rock outcrops of sandstone, dolostone and lacustrine limestone are anticipated at the edges and centre of the floodplain. The limestone and sandstones are expected to be relatively weathered, grading from mostly extremely low and very low strength at its upper surface, to low and medium strength increasing with depth. The dolostone, however, maybe a more competent rock mass with a shallow weathering profile.

4.5 Point 4 to Point 5

DP has no records of investigation within the alluvial soils around the foothills of the Selwyn Range. It is generally anticipated that the subsurface conditions in this portion of the alignment will comprise a mixture of colluvium and sheet wash materials i.e. clays, silts, sands and gravel with some alluvial clayey soils closer to the creeks and channels. The thickness of such soils will increase down slope and are likely to be at least a few metres thick.

4.6 Point 5 to Mt Isa

DP has relatively comprehensive investigation records for the Mount Isa Group of rocks in this section of the alignment, because most of the developed portion of Mount Isa is underlain by this geological unit. These records include quite detailed investigation for developments on the eastern side of the Diamantina Developmental Road, directly adjacent to the alignment.

One of these previous investigations was 500m northeast of the pipeline terminus which encountered relatively uniform conditions, characterised by very stiff and hard residual silty clay and sandy clay with some gravel, overlying siltstone (and shale at some locations) from 0.1 m to 0.7 m depth. The underlying rock was very low to low strength initially, often with some low to medium strength bands, then low and medium strength, high fractured and fragmented within 1.9 m to 3.4 m penetration. High and very high strength rock was also encountered at several locations, below 2.4 m to 2.7 m depth.

Another investigation to the east of the pipeline and approximately 1.5 km south of the terminus indicated dense and very dense predominantly gravel soils up to about 2 m deep, overlying hard silty clay and clayey silt with quartz or chert inclusions. Extremely low strength siltstone was generally encountered from between about 1 m and 4 m depth, and grading to very low strength with depth.

Despite this site being underlain by the same Moondarra Siltstone geological unit, the soils in the southern portion of the same site were generally fine grained and the underlying rock was less weathered, giving rise to slightly stronger rock conditions. Some of this stronger rock was encountered at depths as shallow as about 1 m, and in a high to very strength condition (two bores), yet only low and medium strength rock was encountered below about 4 m depth at another two locations.

Investigation for a proposed bridge over the Leichhardt River in the Mount Isa CBD suggested that the basal sediments are predominantly medium dense sands and gravels, with some minor clay bands. Rock was present from about 2.5 m to 4.0 m depth. Similar conditions are anticipated in Mica Creek, although the rock is probably slightly shallower due to the narrower watercourse.

Investigation for a quarry within the Eastern Creek Volcanics to the west of the Diamantina Developmental Road encountered slightly variable conditions. Metabasalt, where encountered, was very low to low strength and highly weathered to about 7 m depth in one bore, and very high strength, fractured and slightly fractured below about 1.5 m depth (to termination at 3.8 m depth) in another bore. Quartzite, where investigated, was mostly high and very high strength, fractured from less than 1 m depth.

There are no other investigation records for areas to the west of the Diamantina Developmental Road near the proposed alignment.

5. Comments on Potential Engineering Issues

The comments provided in the following sections are based on very limited investigation data, and are largely based on interpretation of map data and aerial imagery. The information given in the following sections should not be used for design purposes, but is provided as an overview of the anticipated potential engineering issues associated with the project.

5.1 Warrego to Point 1

Red earth soils of sand, silt and clay with colluvium and localised scree/sheet wash deposits with some rock outcrops in the eastern and western parts of the section and shallow soil/rocky conditions across the north-west to south-east trending ridge. Rock conditions are likely to comprise folded and faulted partially metamorphosed sedimentary greywacke, siltstone, mudstone and sandstone with some intrusions of Tennant Creek Granite.

Based on the results of previous investigations at Tenant Creek, trenching excavations to about 1.5 m to 2 m depth are likely to encounter relatively strong cemented mixtures of low plasticity clay, silt, sand and gravel. Where shallow rock is encountered it is generally anticipated to be weathered and of relatively low strength, although localised areas of hard rock such as the Tennant Creek Granite should be expected. It is expected such strata could be identified and therefore avoided during construction by undertaking intrusive investigation works and geological mapping prior to final design, otherwise hydraulic hammers, rock saws or possible blasting should be allowed for.

Groundwater is not anticipated to be present at shallow depth, but it may be present during or shortly after the wet season.

The above soils should be readily trafficable with modern plant, although during periods of wet weather any particularly silty and/or clayey soils will soften leading to access difficulties. The soils and weathered weaker rock should be readily removed with a 20 tonne or larger hydraulic excavator fitted with a single tyne ripper.

This section of the alignment is not indicated to be characterised by numerous drainage lines nor watercourses, with the exception of Tennant Creek and its tributaries in the east of the section. It is anticipated that during periods of wet weather they are likely to have moderate to high flow velocities, which could be sufficient to cause moderate scour, thus some scour protection such as local deepening of the pipeline, use of select backfilling materials, cross berms and flexible couplings should be considered. Where such watercourses are encountered they are likely to be accompanied by deeper tracts of alluvium which may contain layers of loose, water-bearing coarse-grained soils.

The results of previous laboratory testing of the soils around Tennant Creek indicate that the silty superficial soils are highly dispersive, thus temporary erosion measures during construction may be required along with select capping materials for the trench. The soils previously tested also generally indicated a “moderate to severe” exposure classification for buried steel and concrete in accordance with AS 2159 – 2009. Special precautions for durability design may therefore be required.

Aerial photographs suggest that landslide and debris flow hazards are unlikely to occur through this section, although suitable precautions should be taken against general instability particularly when crossing watercourses where loose, water-bearing coarse-grained soils maybe present. Similarly, although not anticipated, local instability of excavations should be considered when crossing the ridge due to the folded and faulted nature of the strata which can produce large variations in the orientation of joint sets, which may give rise to instability in some excavation faces.

Previous investigation in the Tennant Creek area has not indicated any significant very loose to loose silt/sand deposits, which would usually be considered susceptible to liquefaction. There is potential for the local occurrence of such deposits across the section and more likely at river and creek crossings. However, they are not considered to be of significant thickness or lateral extent, thus would are not considered to be of major concern with regard to liquefaction.

5.2 Point 1 to Point 2

It is anticipated that similar soil conditions, albeit with a higher sand content, to those encountered in the Tennant Creek investigations will be present in this section. A deeper rock profile and sand dunes/calcrete (gravel) are also expected in the east of the section.

Conditions are expected to comprise cemented (particularly in the east, by calcite) mixtures of clay, silt and gravel, but be predominantly sandy in nature (refer Figure 1) and of relatively strong consistency. The dunes and calcrete areas in the east of the section are expected to be gravel (refer Figure 2).

Figure 1: Anticipated conditions across the sand plain deposits of the Barkly Tablelands.

Figure 2: Conditions at approximately 40 km north of Point 2 within areas mapped as calcrete. Conditions expected to be gravelly in nature

Any rock outcrops or where rock is encountered at shallow depth, it is anticipated to comprise weathered very low to low strength clastic limestone sediments which have been locally chertified and dolomitised, and subsequently would be expected to be of higher strength.

The comments provided in Section 5.1 above should be adhered to with respect to the anticipated engineering conditions. With regard to founding options for the compressor stations and main live valves, it is anticipated that traditional mass concrete footings founded within the superficial soils would be suitable with stiffening to suit an estimated Class H1-D' (highly reactive) classification.

5.3 Point 2 to Point 3

It is expected that similar conditions to those discussed above will be encountered in this section, albeit the localised rock outcrops will become more abundant along with a shallowing soil profile as the hill near the centre of the section is traversed.

The conditions around the base of the hill will essentially comprise cemented mixtures of clay, silt, sand (predominant) and gravel, possibly up to 2 m thick, as encountered along previous sections of the alignment.

The Wonarah Formation which outcrops around the base and covers the crest of the hill is likely to comprise folded and faulted, chertified limestone and mudstone with dolostone, clastic and siltstone/sandstone interbeds. Such strata are not considered to be largely karstic, thus the risk of solution features is considered to be low. These strata are expected to be weathered and of relatively low strength within the depth of excavation, although the dolostone and chertified strata are anticipated to be higher strength and should be avoided where possible, using the aforementioned investigation and mapping measures, otherwise hydraulic hammers, rock saws or possible blasting maybe required.

The comments provided in Section 5.1 above should be adhered to with respect to the anticipated engineering conditions, with the exception that the soils and rocks are anticipated to be of a more alkaline nature due to the presence of limestone, thus are likely to be non-aggressive to buried steel.

With regard to founding options for the main line valve, it is anticipated that traditional mass concrete footings founded within the superficial soils or weathered rock would be suitable with stiffening to suit an estimated 'Class M-D' (moderately reactive) to 'Class H1-D' (highly reactive) or 'Class M-D' (moderately reactive) classifications, respectively.

5.4 Point 3 to Point 4

This section of the alignment comprises a large floodplain of low relief with numerous rivers and creeks dissecting it. The floodplain is characterised by silty clay (*"Black Soil"*) in the west and alluvial clay, silt and sand with minor gravel in the east and an outcrop of lacustrine limestone near the centre of the section.

Access to this section of the alignment is likely to limited to the dry season as the silty clay soils particularly the black soils, will rapidly soften with increases in moisture, eventually becoming untrafficable following sustained periods of wet weather.

Photographs showing access conditions within the black soils during the early dry season at Alroy Downs (some 50 km north-east of Point 2) are presented below as Figures 2 and 3.

Figure 2: Conditions at Alroy Downs during early dry season.

Figure 3: Conditions at Alroy Downs during early dry season.

Trenching excavations to about 1.5 m depth are likely to encounter relatively medium to strong predominantly clay soils with silt and sand layers and extremely low to low strength limestone. These materials should be readily removed with a 20 tonne or larger hydraulic excavator fitted with a single tyne ripper.

The black soils are likely to be highly reactive, thus will be susceptible to large ground movements with regard to seasonal moisture variations. Consideration should therefore be given to deepening the pipeline within such soils to in the order of 2 m (i.e. half the height of suction) to reduce potential

movements, although it is expected that the movements will be relatively uniform along lengths of the pipeline. To achieve such uniform movement suitable reinstatement of trenches will be required to prevent infiltration of any ground (if present) or surface water. This is of particular importance if Gilgai's are present in the area.

It is anticipated that during the wet season the rivers and creeks which dissect the section will contain water at low to moderate flow velocities, however, higher flow rates would be expected during periods of high rainfall or at the start of the wet season. Such flows are anticipated to be sufficient to cause low to moderate scour, thus some scour protection such as local deepening of the pipeline, use of select backfilling materials and cross berms should be considered.

Where such watercourses are encountered, particularly across such an expansive floodplain they are likely to be accompanied by deeper tracts of alluvium which contain layers of loose, water-bearing coarse-grained soils of silt, sand and gravel.

With regard to the occurrence of upland acid sulfate soils (ASS), electronic mapping data indicates a localised 'high probability of occurrence' along this section of the alignment. The areas are generally located adjacent to or at the confluence of creeks and rivers.

It is expected that clayey black soils will be of low dispersion potential, whilst the alluvial soils in the west will be moderately dispersive, thus temporary erosion measures during construction along with select capping materials for the trench may be required. With respect to aggressivity, a "mild to moderate" exposure classification for buried steel and concrete in accordance with AS 2159 – 2009 is anticipated, although a higher classification may be necessary if ASS conditions are found.
Instability of excavations should be considered where thick coarse-grained soils are encountered and particularly where construction personnel are to enter. Instability will be more likely where such soils are encountered near rivers and creeks, and are water-bearing. Excavation in such conditions may require the use of trench support and localised dewatering.

No investigation data is available for this section with regard to the presence of silt/sand deposits, however, based on the anticipated conditions such, strata are only expected at river and creek crossings, and are unlikely to be present in very loose or loose condition and of significant thickness or lateral extent, thus would are not considered to be of major concern with regard to liquefaction.

With regard to founding options for the compressor station and main line valve in this section, it is anticipated that traditional mass concrete footings founded within the superficial soils would be suitable with stiffening to suit estimated classifications of 'Class H1-D' (highly reactive) for the alluvium or 'Class E-D' (extremely reactive) for the black soil.

5.5 Point 4 to Point 5

Subsurface conditions are expected to comprise a mixture of colluvium and sheet wash materials (i.e. clays, silts, sands and gravel with some alluvial clayey soils) closer to creeks and channels in this section.

The above soils are expected to be of similar composition to the alluvial soils described in the previous section, albeit with some coarser materials due to their closer proximity to the parent materials. Thus, the engineering comments provided above for the alluvium should be adhered to.

5.6 Point 5 to Mt Isa

Shallow rock conditions are expected for most of this section, from about 82 km east of Point 4, and in other localised sections underlain by Gunpowder Creek Formation and Yaringa Metamorphics.

Based on the results of previous investigations, trenching excavations to about 1.5 m depth in the Mount Isa Group rocks are likely to encounter relatively strong residual clays and very low to low strength rock with some medium strength bands. These materials should be readily removed with a 20 tonne or larger hydraulic excavator fitted with a single tyne ripper. While no previous investigation has been carried out in the Sybella Granite unit, the relatively low surface relief in most of this suggests that this unit has a relatively deep weathering profile and no specific additional precautions are expected to be needed for trenching.

Up to about 1 m of overburden is expected over the Eastern Creek Volcanics, Leander Quartzite and May Downs Gneiss units. Some high to very high strength rock is expected within these units, and excavation is generally anticipated to require the assistance of hydraulic hammers, especially in higher surface relief terrain.

The results of previous laboratory testing in the Mount Isa area and specifically the Mount Isa Group indicates that the soils are mostly non-sodic. Similar conditions are anticipated for other rocks within the Mount Isa Inlier. On this basis, dispersive type erosion is not expected to be a concern in this section of the alignment. Similarly, the soils previously tested have generally been indicated to have a "non aggressive" exposure classification for buried steel and concrete in accordance with AS 2159 – 2009. Special precautions for durability design are therefore not anticipated to be necessary.

Suitable precautions should be taken in the Mount Isa Inlier to protect construction workers from naturally occurring heavy metals in the soil and rock. Apart from standard dust suppression requirements, special attention should be paid to hand hygiene prior to meal breaks, to prevent the inadvertent ingestion of soil with potentially elevated heavy metal concentrations. Proprietary hand towels with special cleaners to remove and bind lead and other heavy metals are often used in the Mount Isa area to assist in this regard.

Aerial photographs suggest that landslide and debris flow hazards are unlikely to occur, although suitable precautions should be taken against general instability when undertaking civil works in the more steeply sloping portions of this section (especially when working on the ridge up to RL 450 which is underlain by Leander Quartzite). Local instability of excavations should always be considered when construction personnel are entering excavations. This is because there is a large variation in the orientation of joint sets in the Mount Isa region, which may give rise to instability in some excavation faces, even where uniform face orientations and batter slopes may be adopted.

Previous investigation within the Leichhardt River has not indicated any very loose to loose sands, which would usually be considered as susceptible to liquefaction. While river and creek sediments can vary due to stream velocity and the origin of sediments, previous experience suggests that that

most creek and river sediments in the Mount Isa area are generally relatively coarse. Hence, liquefaction for creek crossings in this section of the alignment are not expected to be a major concern.

Access conditions, although good during the dry season, deteriorate quickly with increases in moisture, particularly areas underlain by soils predominately comprising clay and/or silt.

Photographs showing access conditions during the wet season at Mica Creek i.e. the eastern end of the alignment are presented below as Figures 5 and 6.

Figure 5: Conditions at Mica Creek during wet season.

Figure 6: Conditions at Mica Creek during wet season.

6. Seismic Hazards

Seismic hazard areas are areas that are subject to a severe risk of earthquake damage as a result of seismically induced ground shaking, differential settlement, or soil liquefaction.

According to information provided by the Queensland University Advanced Centre for Earthquake Studies, Geoscience Australia and Earthquake Track a minimal amount of earthquakes have been recorded across most of the route within the last 60 years. However, at the western end of alignment at or near Tennant Creek numerous earthquakes mostly of low magnitude have been recoded up until recently (refer Figure 7). The most notable earthquakes were in January 1988 when three quakes measuring between magnitude 6.4 and 6.9 on the Richter scale were recorded over a period of one day. It was noted that the Darwin to Alice Springs pipeline was shortened by 1 m during this event.

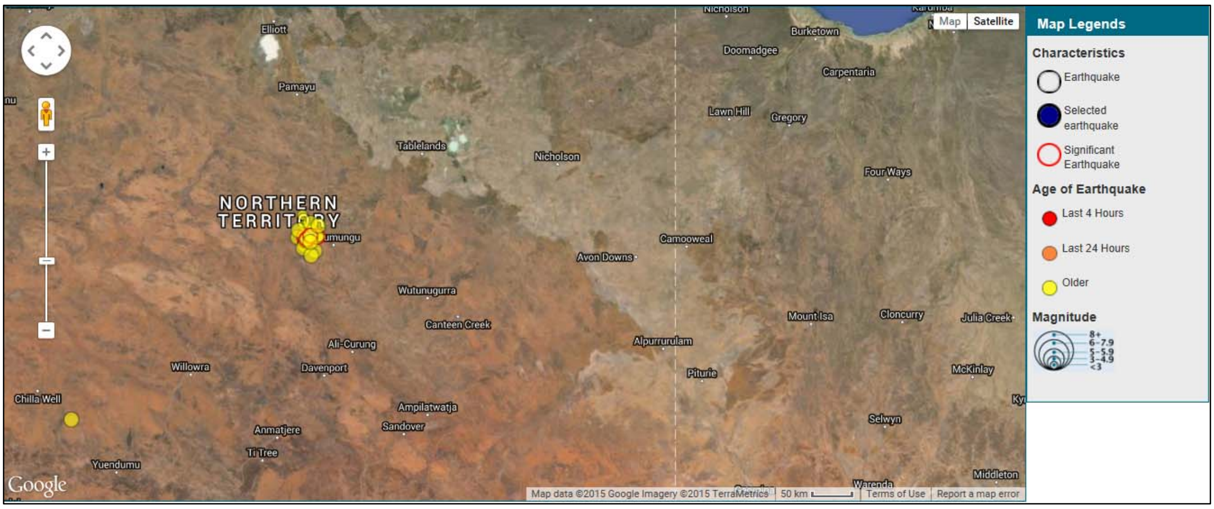

Figure 7: Extract form Geoscience Australia Earthquake mapping showing recent earthquake activity along alignment.

Further research of the Geoscience Australia - Earthquake Hazard Map of Australia, 2012 indicated similar conditions to those anticipated from the above (refer Figure 8).

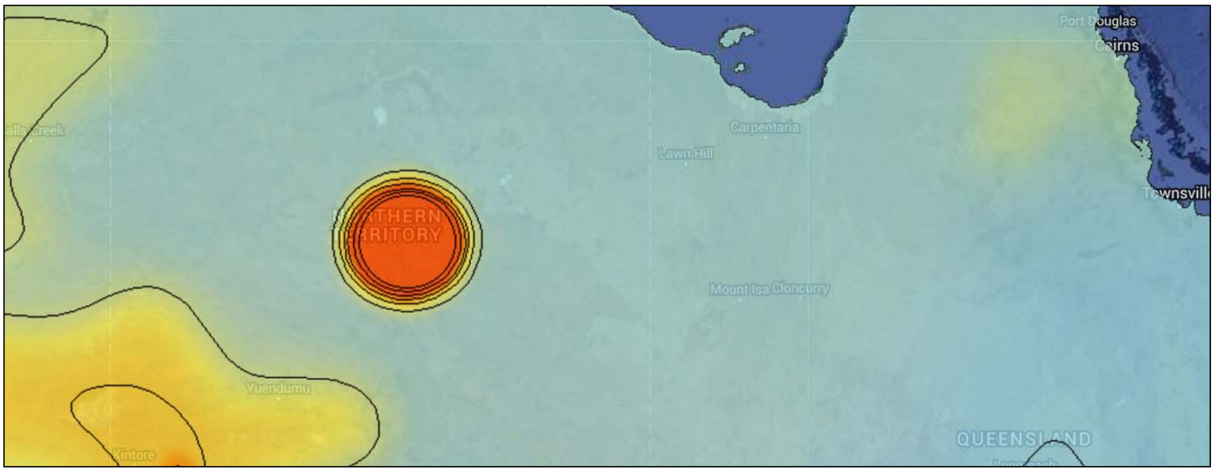

Figure 8: Extract of Geoscience Australia - Earthquake Hazard Map of Australia, 2012

Given the above it is considered the alignment is within a low seismic risk areas with the exception of the western end which is in a moderate to high seismic risk area.

7. Recommendations for Further Investigation

The following investigation works are recommended prior to final design:

- site inspection and additional detailed desktop review;
- intrusive investigation, comprising test pits and shallow bores positioned to target crossing, geological conditions and changes in relief;

- laboratory testing to assess reactivity, dispersion potential, aggressivity, strength and compaction characteristics of soils and rock;
- the presence and severity of acid sulfate soils;
- hydrological assessment of the alignment including potential river and creek flow velocities and scour potential; and
- seismic hazards assessment including assessment of liquefaction and active faults.

8. Limitations

DP has prepared this report for the proposed North East Gas Interconnector Pipeline alignment from Tennant Creek to Mount Isa in general accordance with DP's Proposal DWN150078 dated 17 June 2015 and acceptance received from Richard Henderson of Jemena Pty Ltd purchase order 4100115336 dated 23 June. The work was carried out under DP's "Conditions of Engagement". This report is provided for the exclusive use of Jemena Pty Ltd for this project only and for the purposes described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report, DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the desktop study are indicative of the subsurface conditions shown on the reference geological maps and conditions can change abruptly due to variable geological processes and also as a result of human influences.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required by the Health and Safety Legislation and Regulations, to be included in a safety report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

Notes About this Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

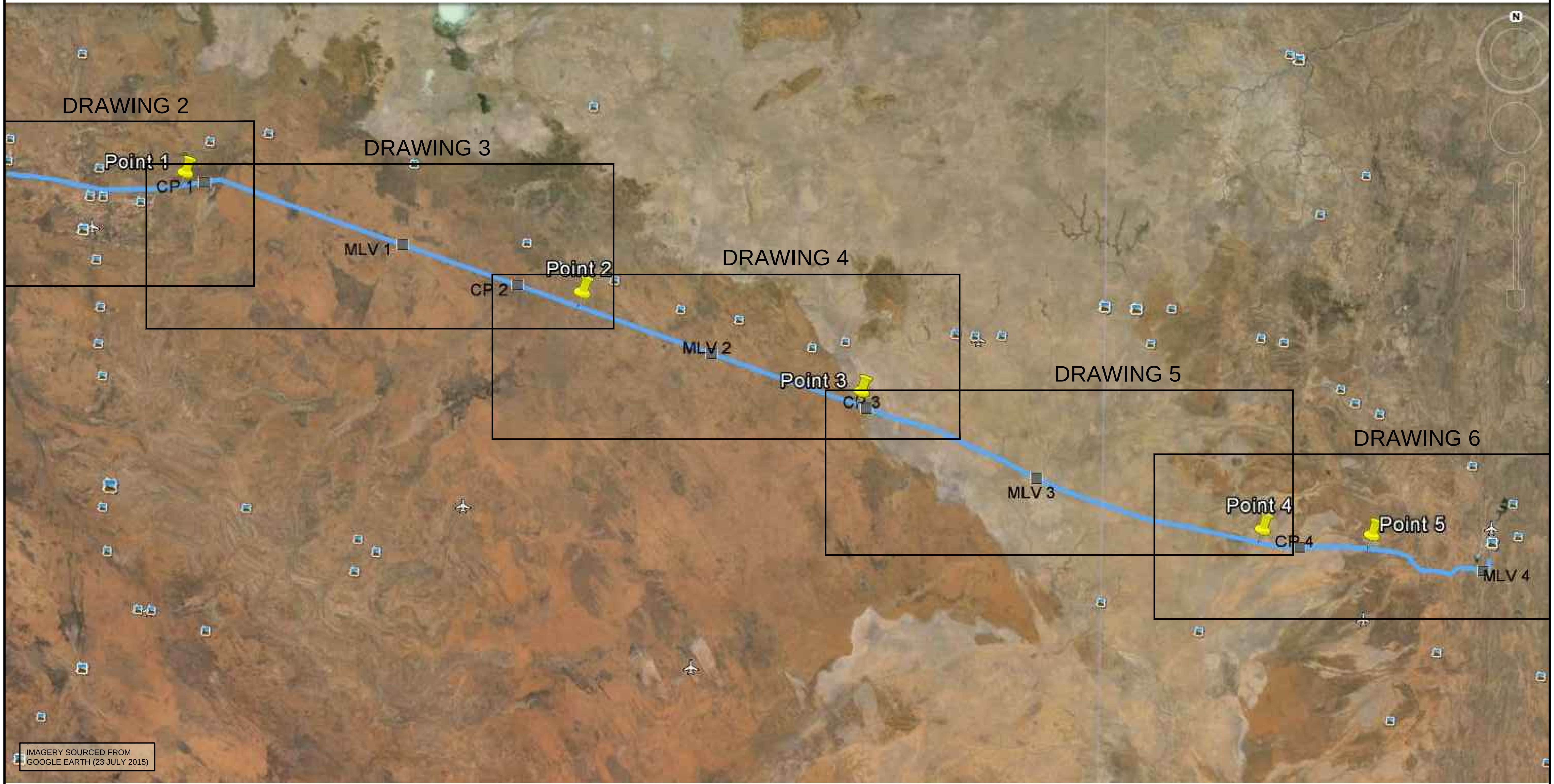
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawings 1 to 6



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	OFFICE: BRISBANE	DRAWN BY: KJR
	SCALE: 1:1500000 @ A3	DATE: JULY 2015

TITLE: **PLAN OF PROPOSED PIPELINE ALIGNMENT**
PROPOSED NORTH EAST GAS INTERCONNECTOR PIPELINE
TENNANT CREEK TO MOUNT ISA

PROJECT No:	87536
DRAWING No:	1
REVISION:	1

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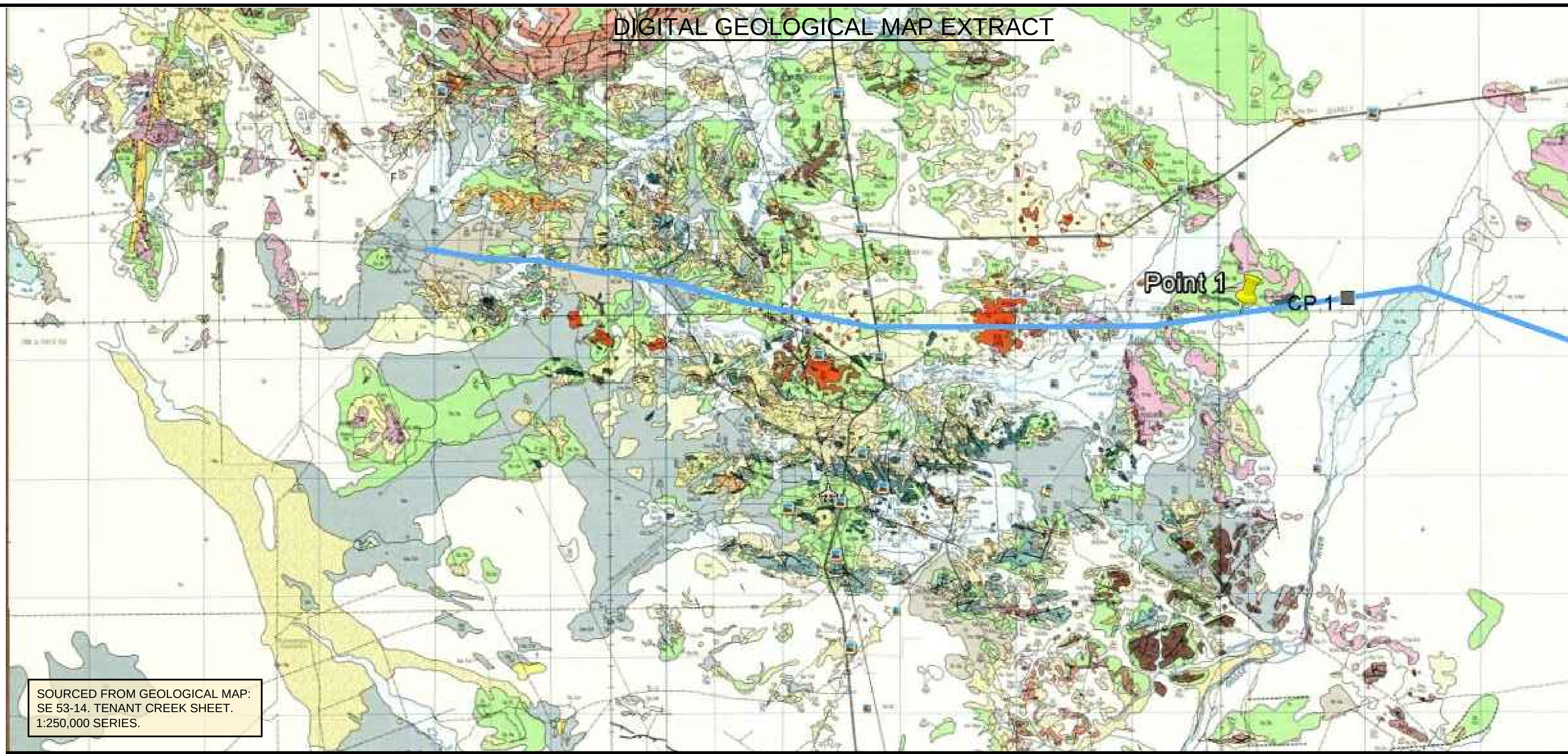

FOR CONTINUATION REFER DRAWING 3

FOR CONTINUATION REFER DRAWING 3

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	OFFICE: BRISBANE	DRAWN BY: KJR	**PROPOSED NORTH EAST GAS INTERCONNECTOR PIPELINE**
	SCALE: 1:500000 @ A3	DATE: JULY 2015	**TENNANT CREEK TO MOUNT ISA**

N

PROJECT No:	87536
DRAWING No:	2
REVISION:	1

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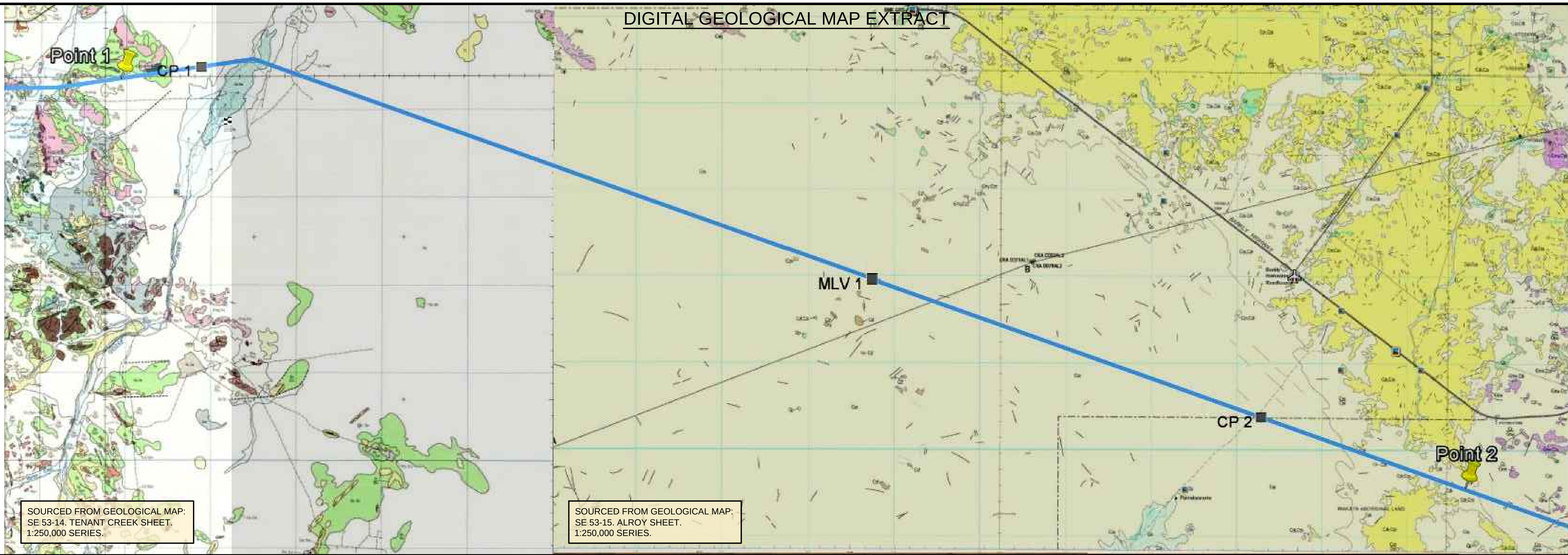

FOR CONTINUATION REFER DRAWING 4

FOR CONTINUATION REFER DRAWING 2

FOR CONTINUATION REFER DRAWING 4

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OFFICE: BRISBANE	DRAWN BY: KJR	**PROPOSED NORTH EAST GAS INTERCONNECTOR PIPELINE**	DRAWING No: 3
SCALE: 1:500000 @ A3	DATE: JULY 2015	**TENNANT CREEK TO MOUNT ISA**	REVISION: 1

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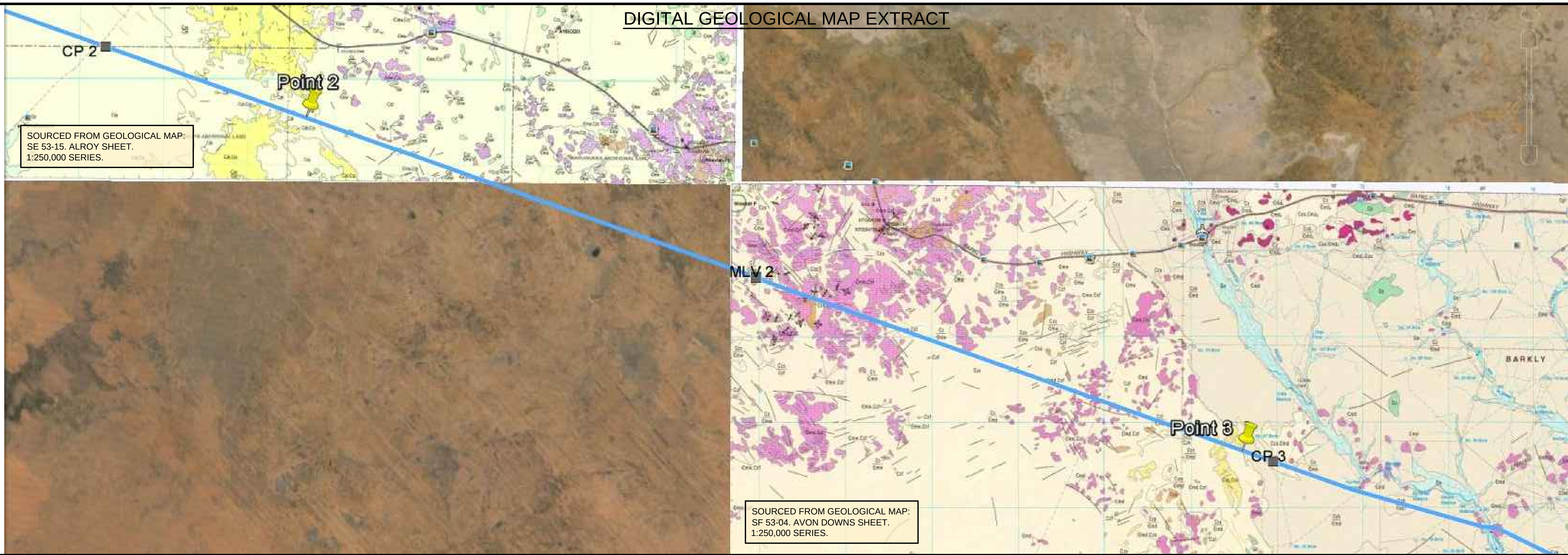
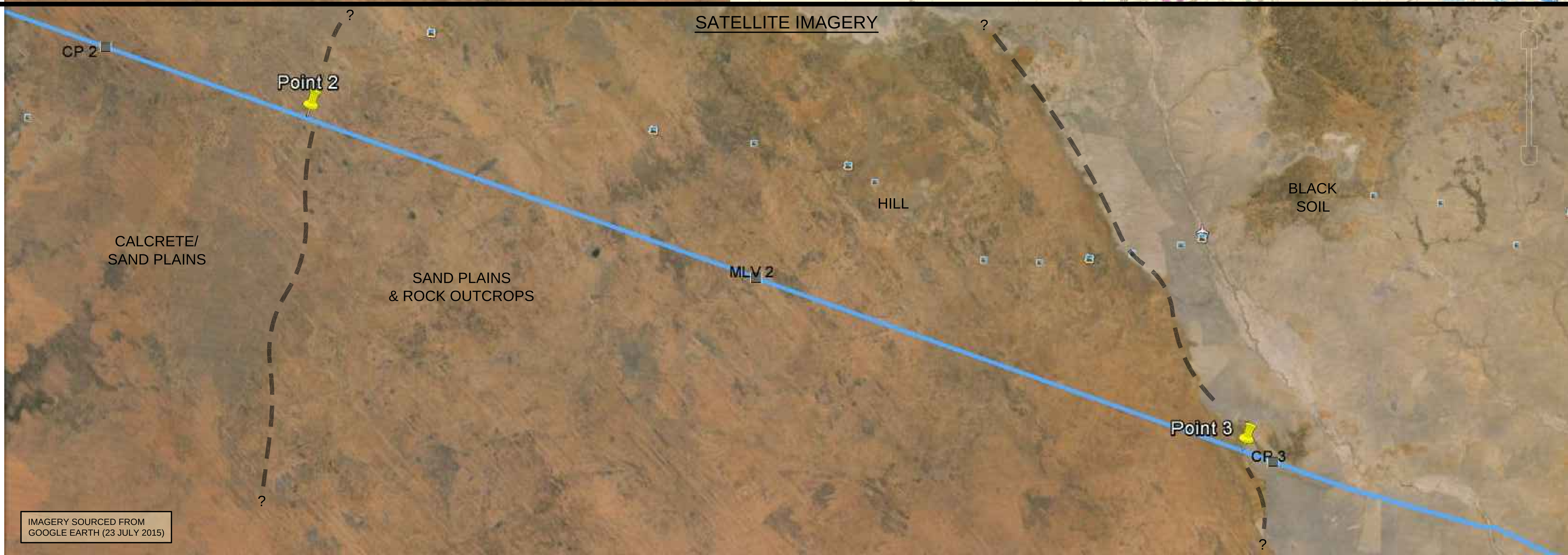
FOR CONTINUATION REFER DRAWING 3

FOR CONTINUATION REFER DRAWING 5

DIGITAL GEOLOGICAL MAP EXTRACT



SATELLITE IMAGERY



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Geotechnics | Environment | Groundwater

CLIENT: JEMENA PTY LTD		
OFFICE: BRISBANE	DRAWN BY: KJR	
SCALE: 1:500000 @ A3	DATE: JULY 2015	

TITLE: **TOPOGRAPHICAL & GEOLOGICAL CONDITIONS: POINT 2 - 3**
PROPOSED NORTH EAST GAS INTERCONNECTOR PIPELINE
TENNANT CREEK TO MOUNT ISA

N

PROJECT No:	87536
DRAWING No:	4
REVISION:	1

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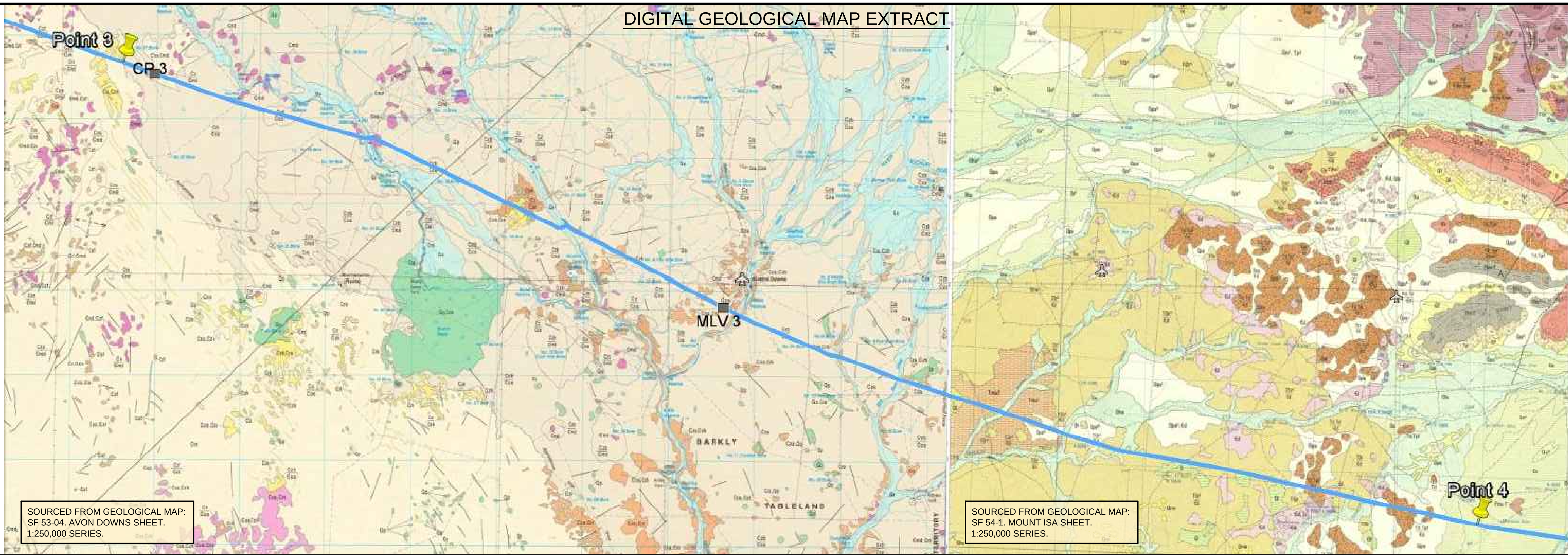

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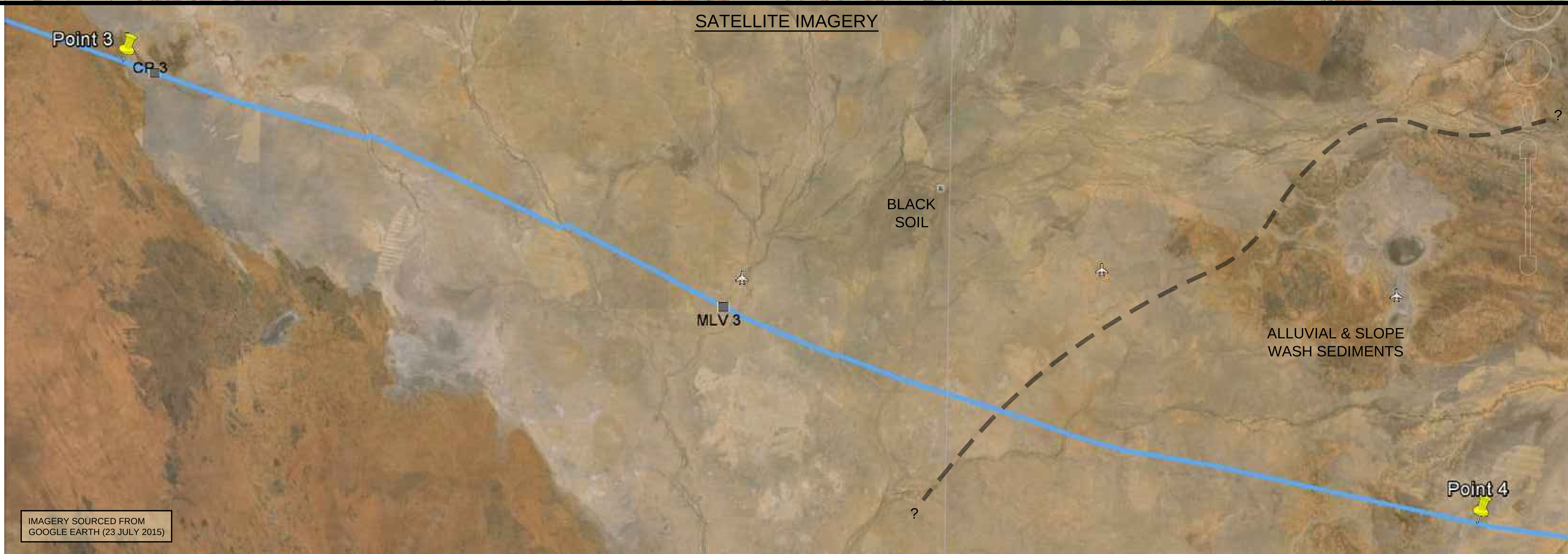
FOR CONTINUATION REFER DRAWING 4



FOR CONTINUATION REFER DRAWING 6

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CLIENT: JEMENA PTY LTD		TITLE: **TOPOGRAPHICAL & GEOLOGICAL CONDITIONS: POINT 3 - 4**	PROJECT No: 87536
OFFICE: BRISBANE	DRAWN BY: KJR	**PROPOSED NORTH EAST GAS INTERCONNECTOR PIPELINE**	DRAWING No: 5
SCALE: 1:500000 @ A3	DATE: JULY 2015	**TENNANT CREEK TO MOUNT ISA**	REVISION: 1

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FOR CONTINUATION REFER DRAWING 5

DIGITAL GEOLOGICAL MAP EXTRACT

FOR CONTINUATION REFER DRAWING 5

SATELLITE IMAGERY

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CLIENT: JEMENA PTY LTD		TITLE: **TOPOGRAPHICAL & GEOLOGICAL CONDITIONS: POINT 4 - MT ISA**	PROJECT No: 87536
OFFICE: BRISBANE	DRAWN BY: KJR	**PROPOSED NORTH EAST GAS INTERCONNECTOR PIPELINE**	DRAWING No: 6
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N